Comparisons of Multilayered Cloud Products from CERES MODIS, CALIPSO and CloudSat Data

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Outline

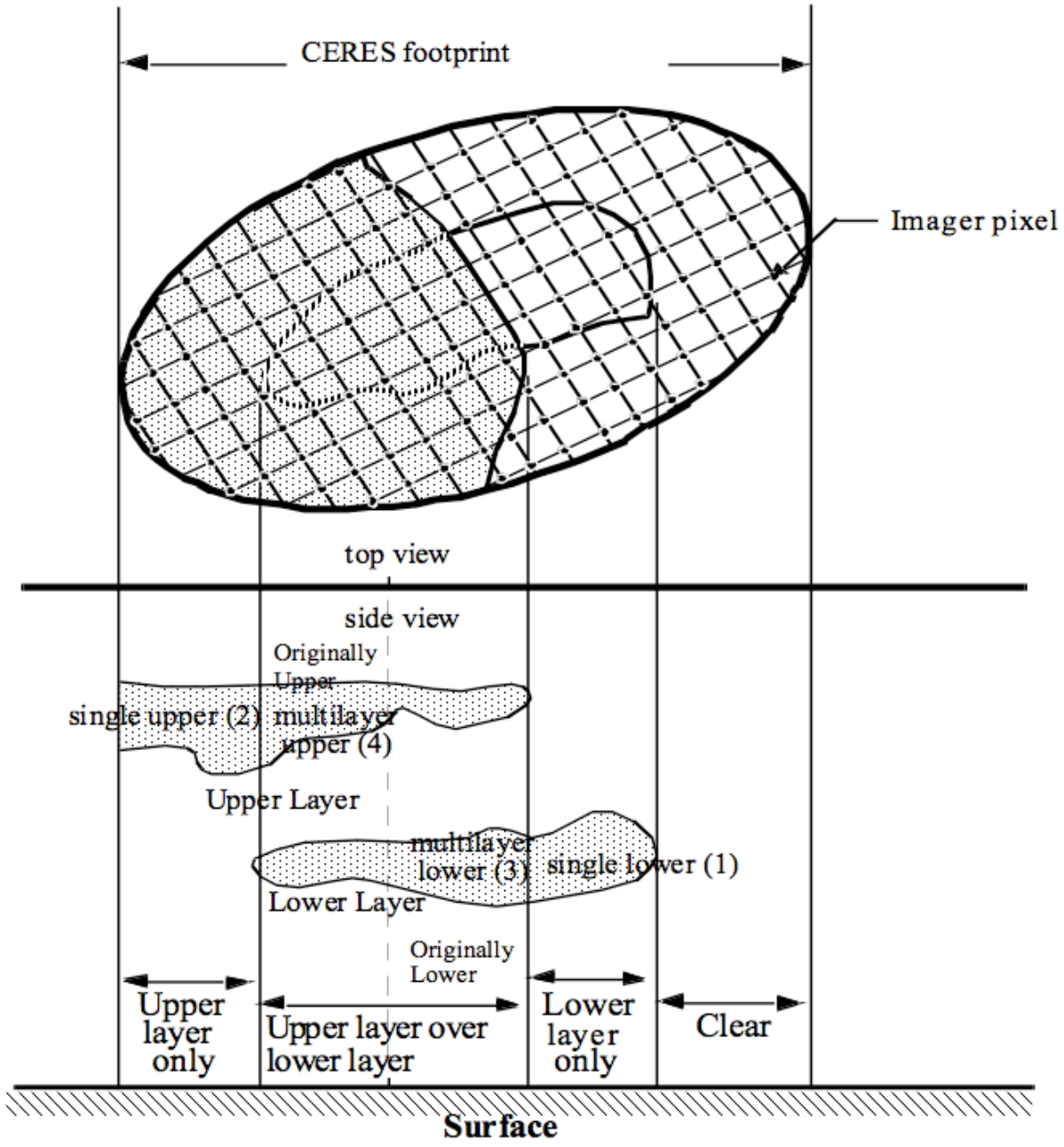
- Introduction of the exploratory CERES MODIS multilayered cloud retrieval algorithm.
- Evaluation of the CERES multilayered cloud property retrievals by comparisons with the CALIPSO and CloudSat data.
- Improvement towards Edition 4.

Objective

- To report the current status of CERES multilayered cloud retrieval.

**CERES – Clouds and the Earth's Radiant Energy System*
**CALIPSO – Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation*
**CloudSat – A cloud radar satellite instrument*

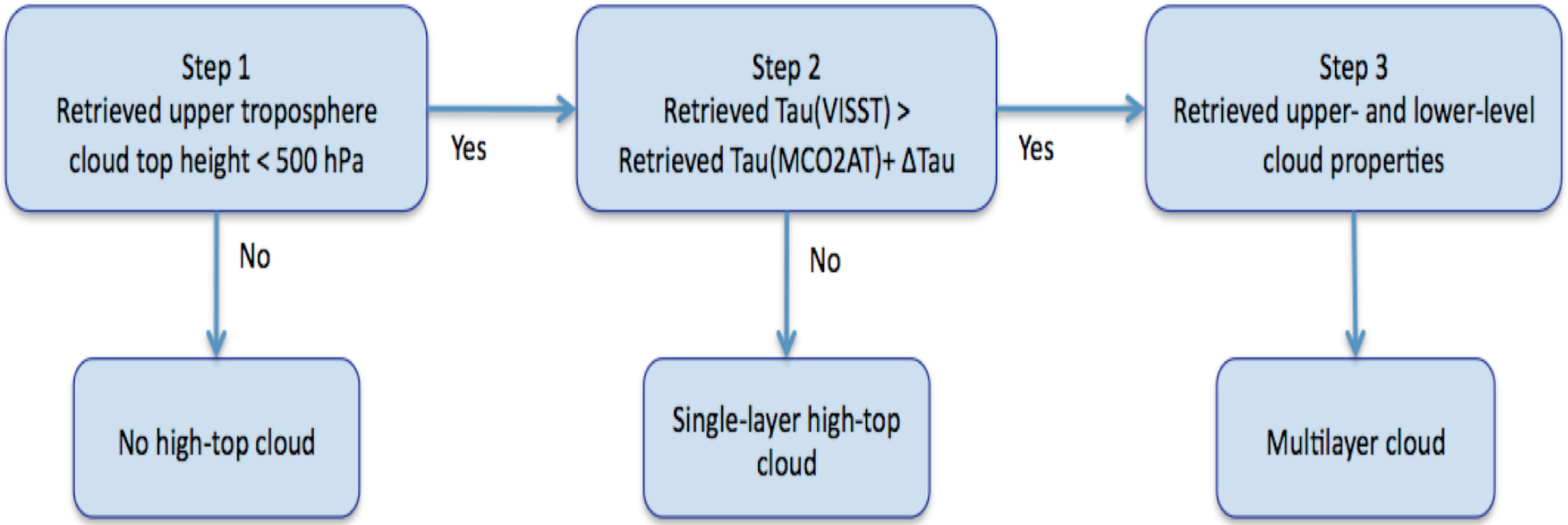
CERES Multilayered Cloud Retrieval Algorithm



The algorithm uses a two-layered cloud model to retrieve both an upper-layer and a lower-layer cloud properties, especially for a pixel containing upper cirrus overlapped with lower stratus clouds.

Application of the Multilayered Cloud Retrieval Algorithm

- Require minimum, a CO2-absorption 13.3-μm channel, as well as the traditional VIS (0.63μm), IR (11μm) and NIR (3.7μm) window channels.



Chang et al. (2010a, b)

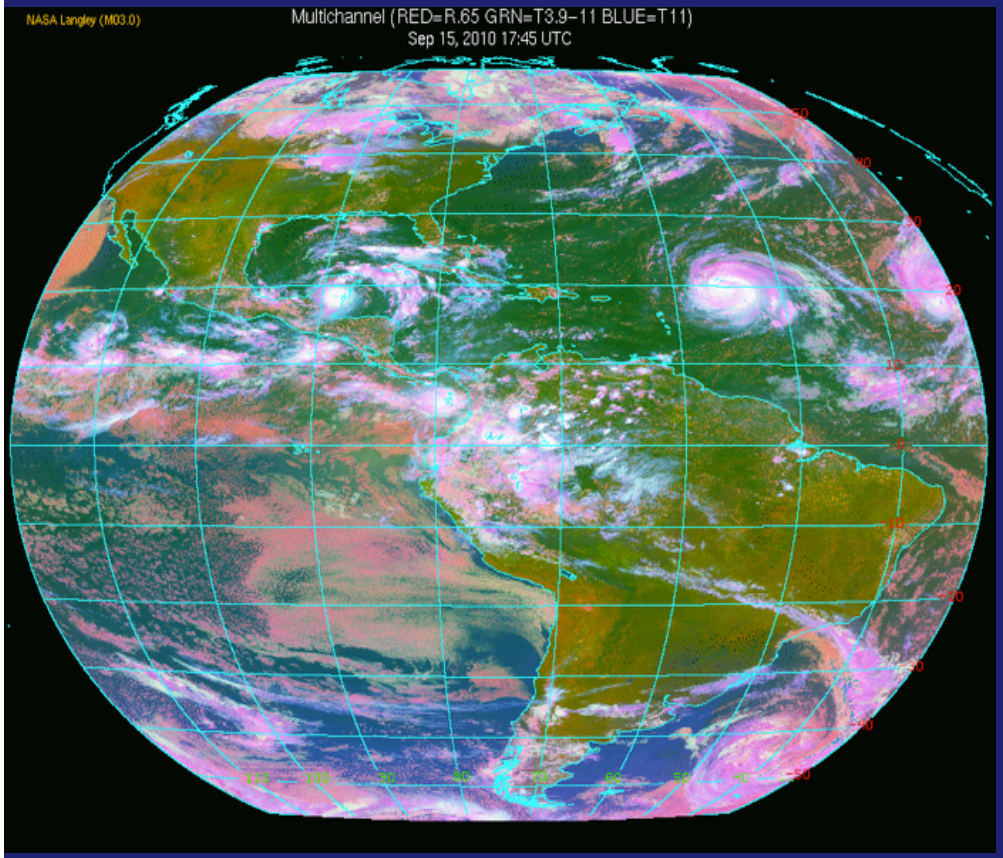
Chang and Li (2005a, b)

CERES Algorithm (in preparation)

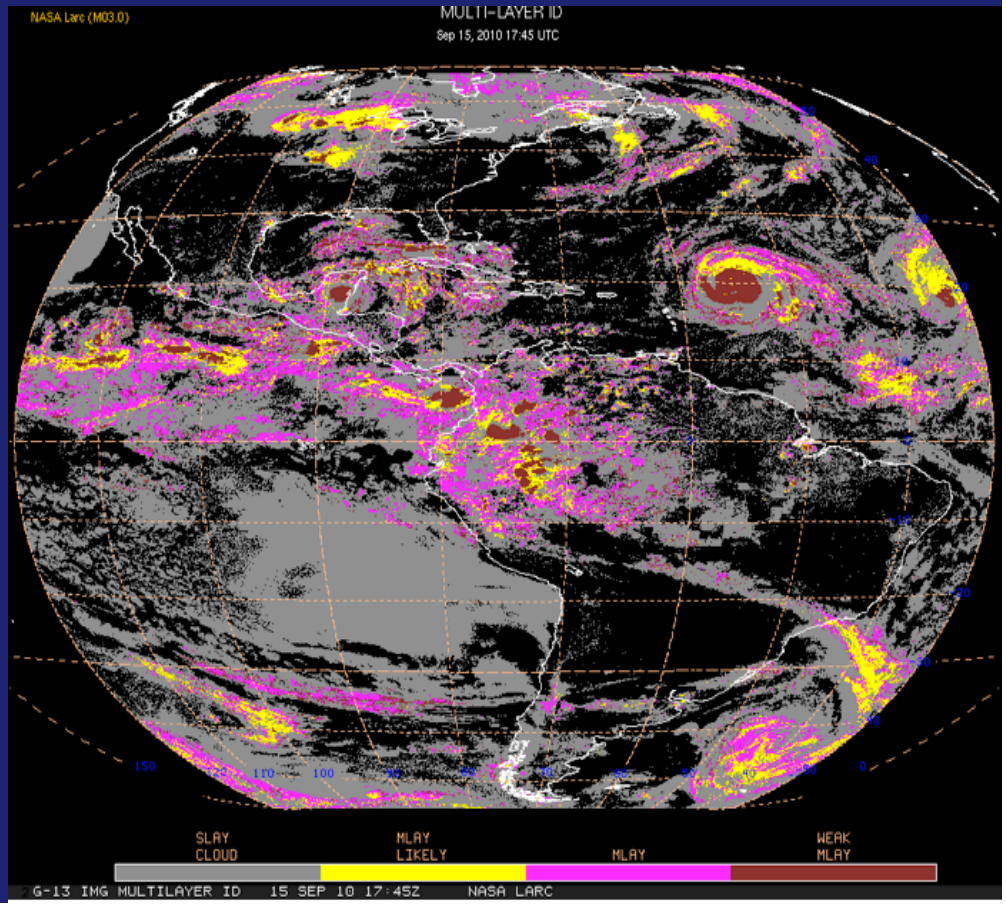
Experimental Test of the Multilayered Cloud Algorithm on GEOs

- The new exploratory multilayered cloud retrieval algorithm has been tested to provide pixel-by-pixel multilayered cloud properties on the CERES MODIS as well as on the GOES-12, -13 and Meteosat-8, -9.

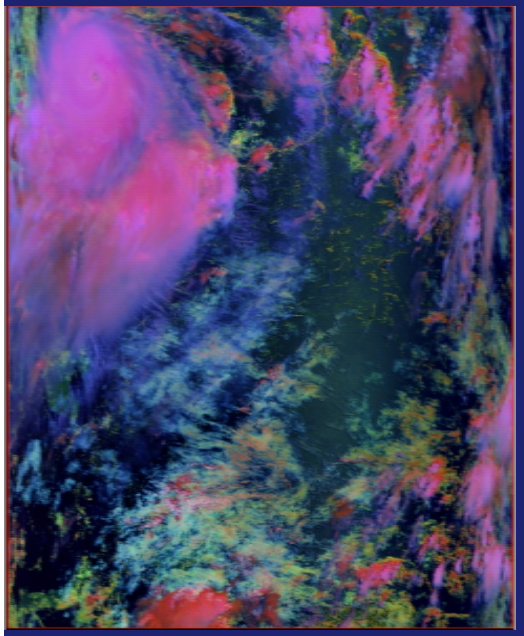
GOES-13 Image (2010.09.15 17:45Z)



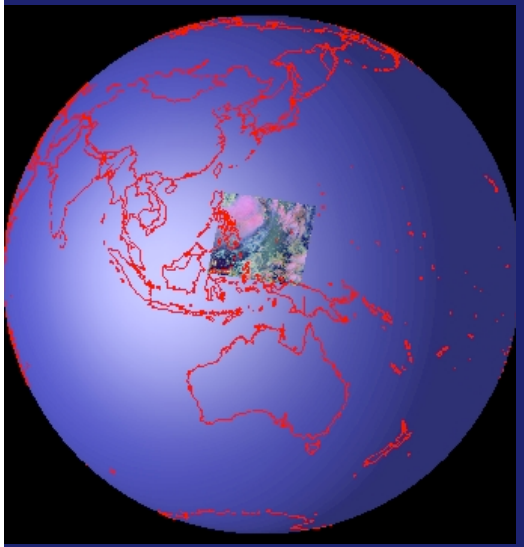
3-level Multilayered Cloud Mask



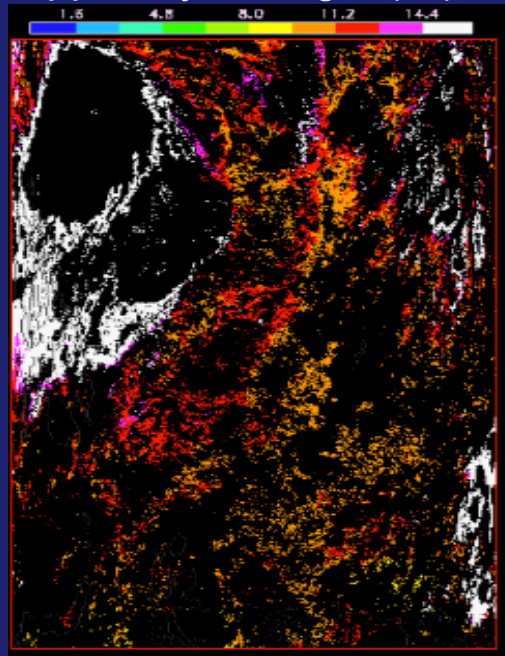
MODIS RGB Imag



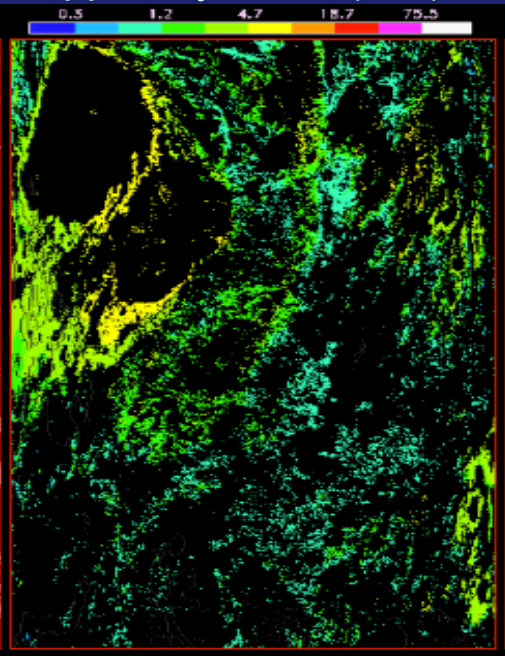
2007.08.15 0150



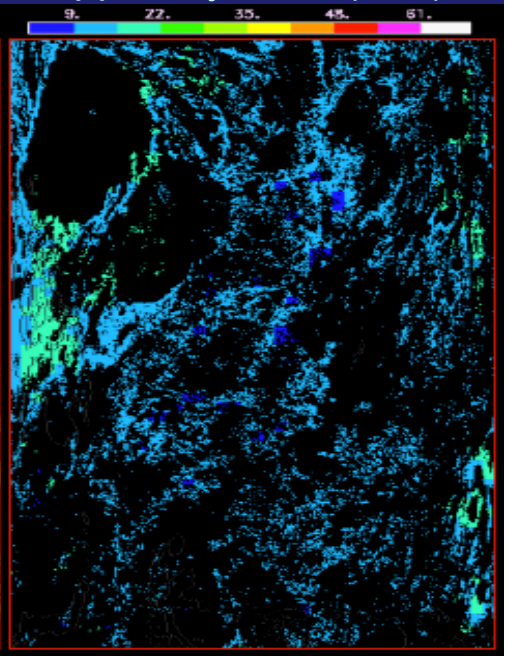
Upper-layer Height (IR)



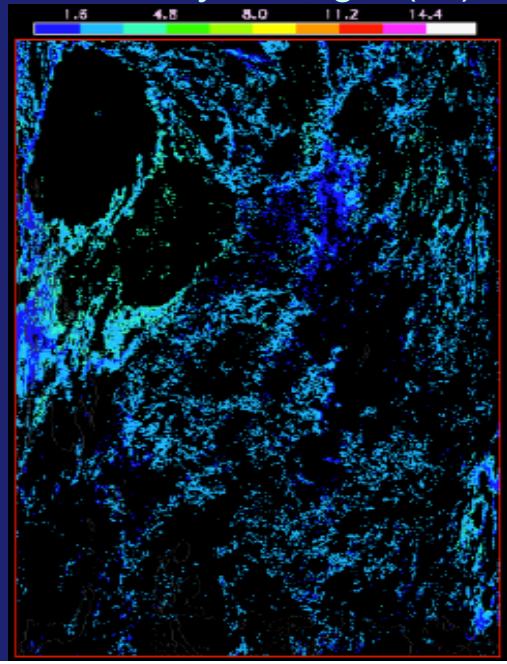
Upper-layer Tau (VIS)



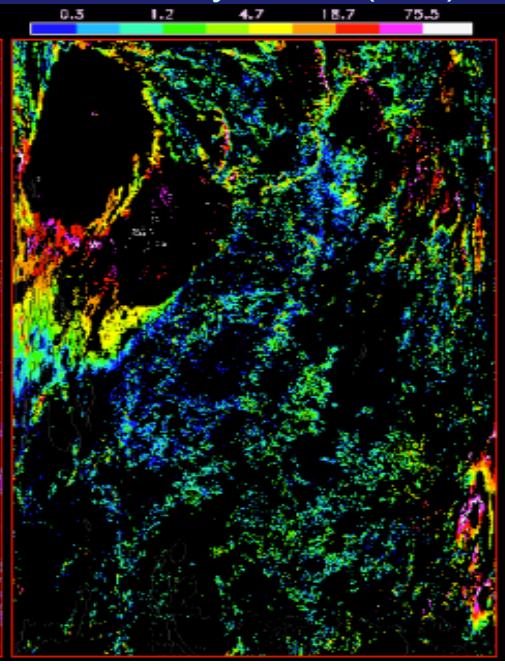
Upper-layer Re (NIR)



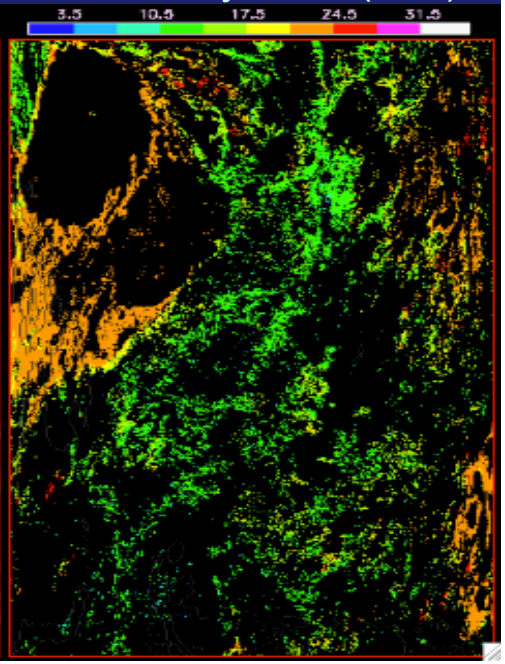
Lower-layer Height (IR)



Lower-layer Tau (VIS)



Lower-layer Re (NIR)



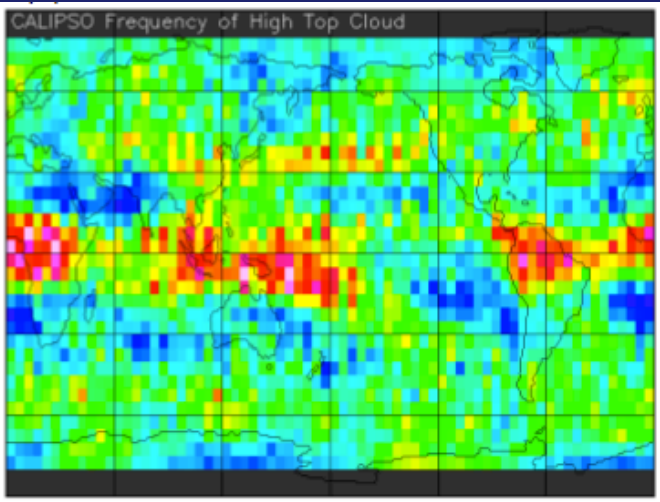
Dataset Used for Evaluation of the CERES Multilayered Cloud Retrieval Algorithm

A-Train Matched MODIS, CALIPSO and CloudSat Data from 2006/07, 2006/10, 2007/01 and 2007/04

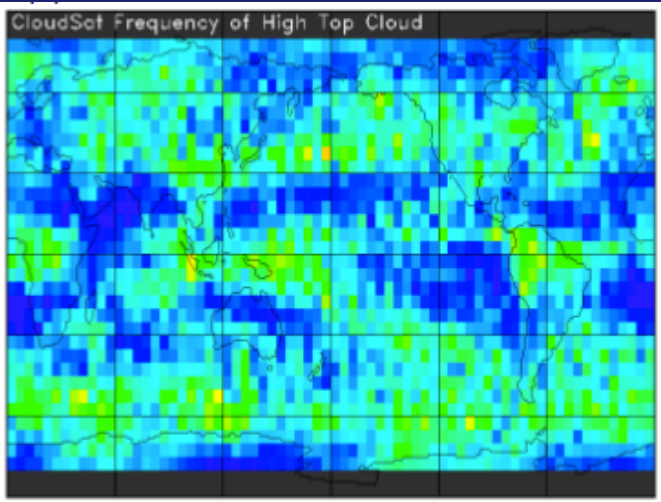
(Note: CALIPSO products are Version 2)

Comparisons of High Clouds and Multilayered Clouds (April 2007)

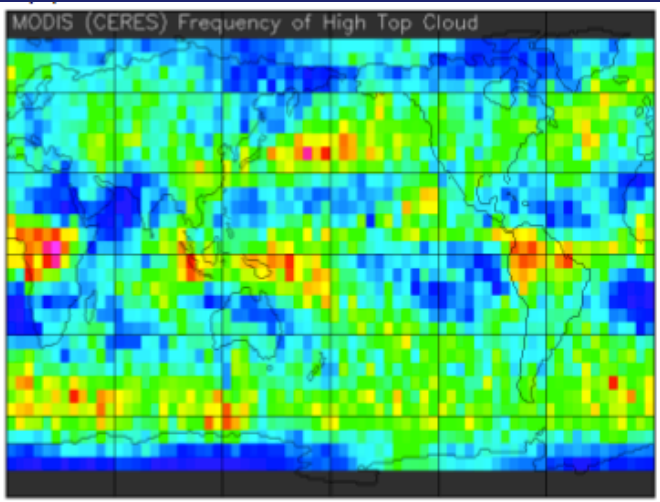
CALIPSO high clouds



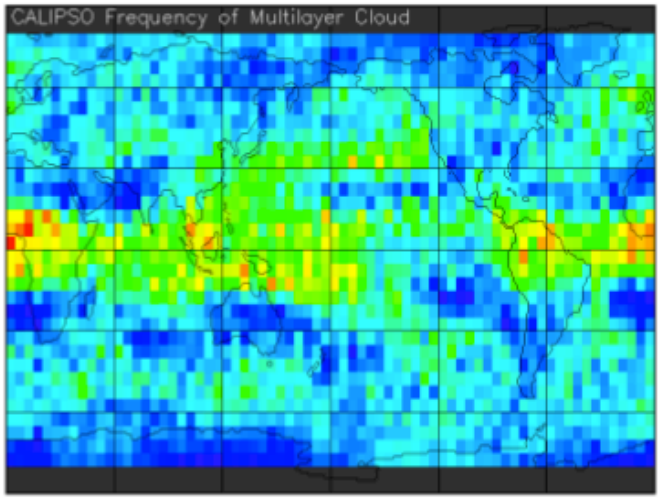
CloudSat high clouds



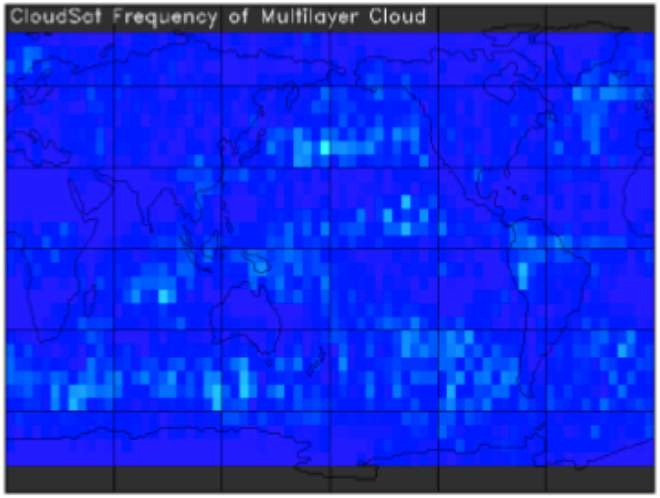
CERES high clouds



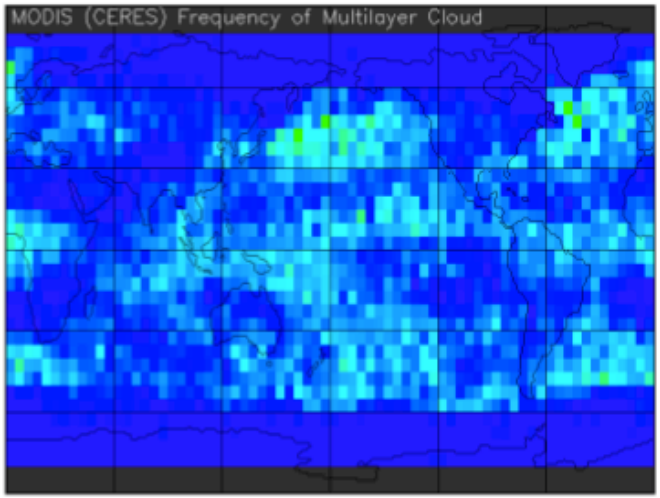
CALIPSO Multilayered



CloudSat Multilayered

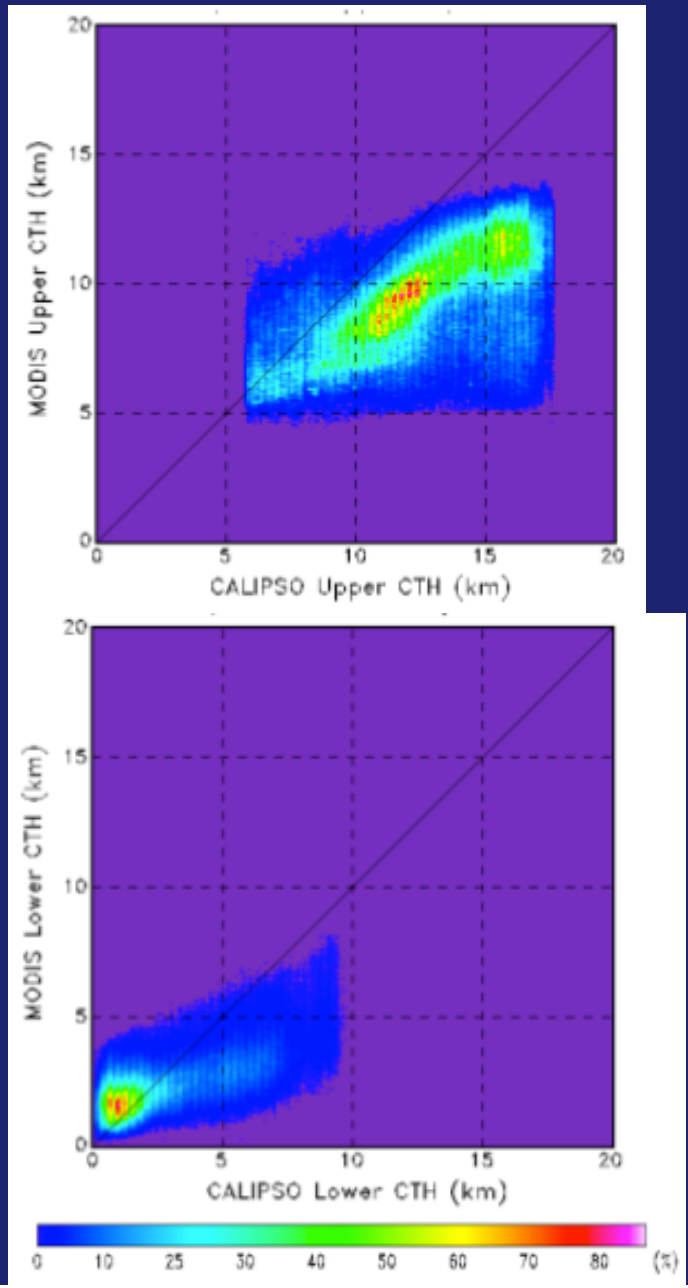


CERES Multilayered

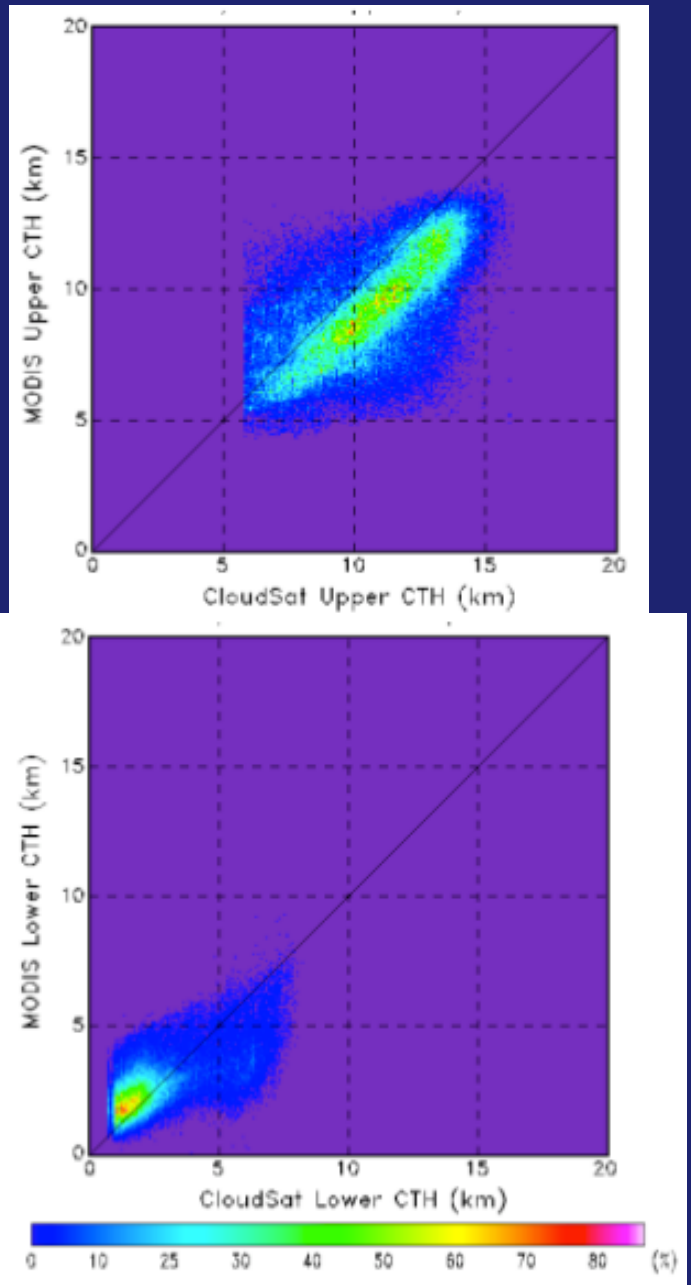


Comparisons of Upper- and Lower-layer Cloud Top Heigt (April 2007)

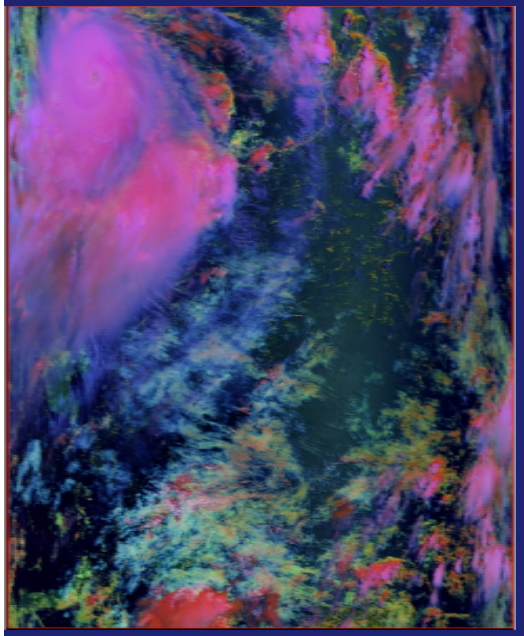
CERES vs CALIPSO



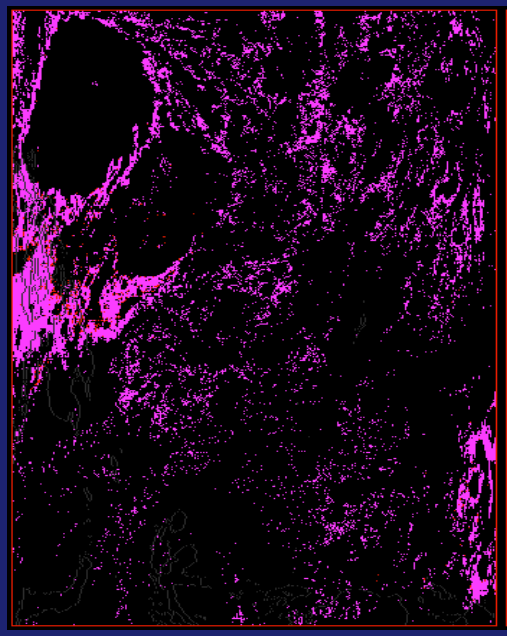
CERES vs CloudSat



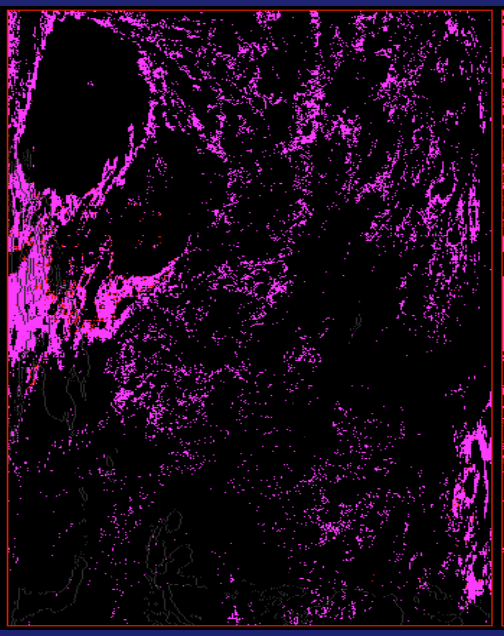
RGB Imag



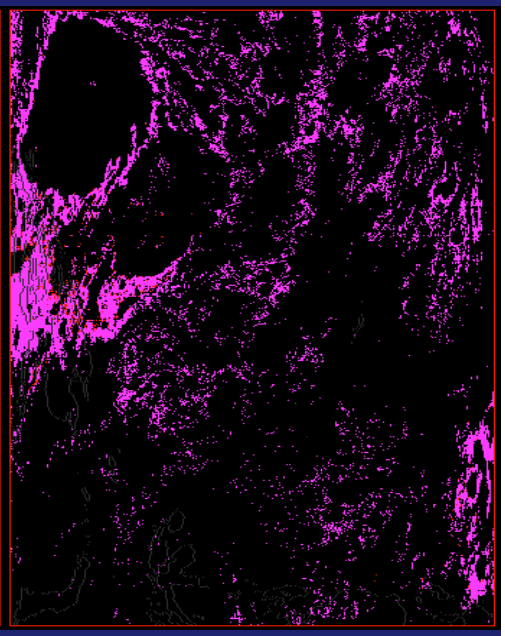
Multilayer mask 1



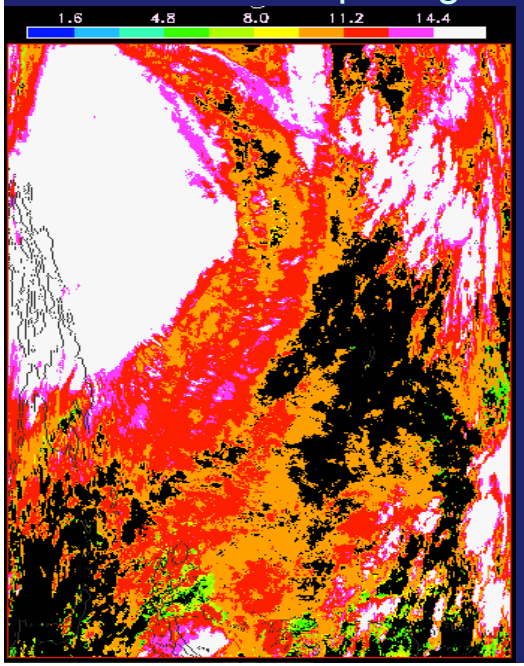
Multilayer Mask 2



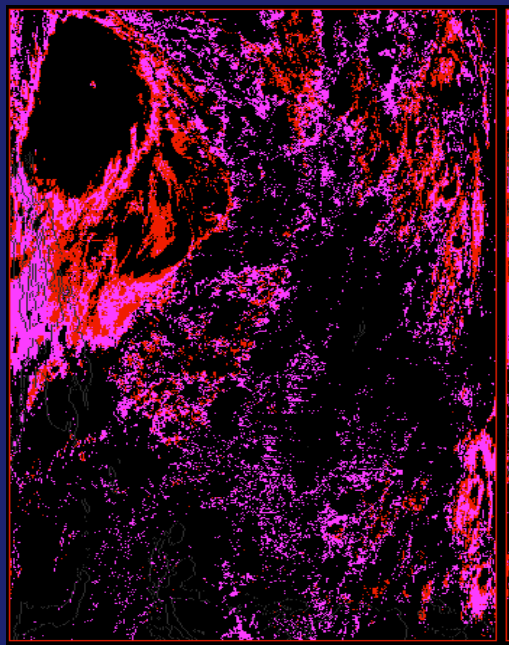
Multilayer Mask 3



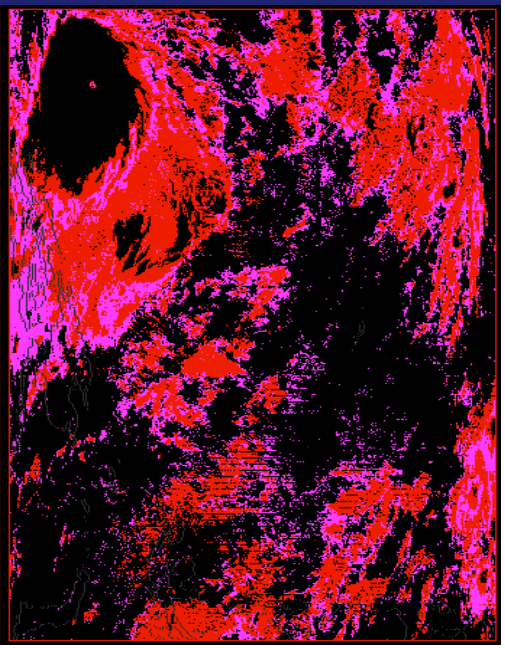
MCO2 Cloud Top Height



Multilayer Mask 4

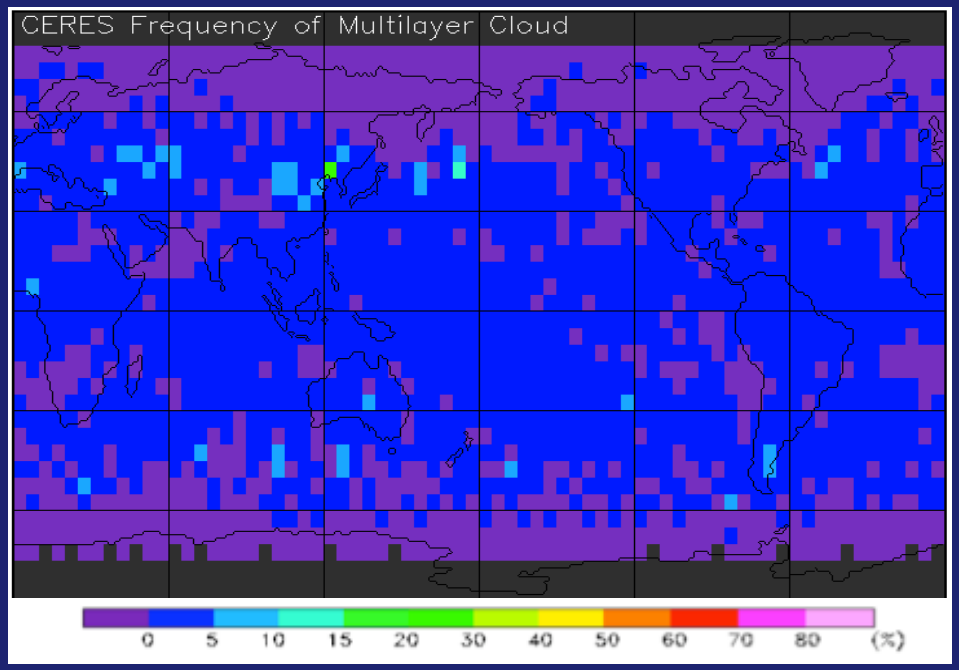


Multilayer Mask 5

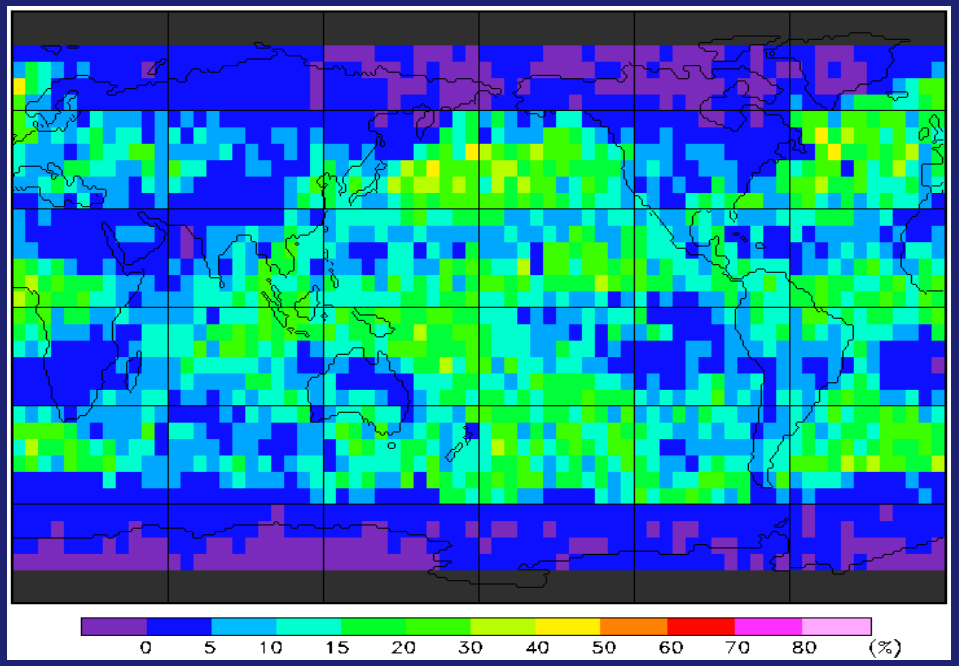


Projected CERES Multilayered Cloud Amounts?

High confidence-level multilayered cloud amount



Low confidence-level multilayered cloud amount



Concluding Remarks

- Conventional single-layered cloud assumptions lead to erroneous results in passive satellite retrieved cloud properties for multilayered cloud systems. The CERES project strives to develop an exploratory multilayer cloud data product using the MODIS data.

- It is possible and important to improve the passively retrieved upper- and lower-layer cloud properties that often consist of multilayered ice over water cloud conditions.

- The A-Train active satellite sensing are ideal for observations of multilayered cloud vertical structure. Unfortunately, they are limited by nadir-only pointing observations. Until the challenge of actively sensing clouds on large spatial and temporal scales are overcome, it is necessary to develop and test novel techniques for retrieving multilayered cloud properties using passively sensed radiances.